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ABSTRACT

The Learning in Science Project (Primary)--LISP(P)--investigated the questions and explanations primary children have about rocks. Data were collected during teaching sessions from New Zealand students (ages 8-11) and Australian students (ages 10-11). The teaching sessions required the teacher to create a situation in which children generated some questions about rocks. Students were then invited, either individually or in small groups, to offer possible answers to these questions. Additional data were collected during individual interviews. The majority of questions raised by students focused on the formation, composition, location, color, and durability of rocks. Specific questions generated and some of the explanations offered for each of these question areas are presented and analyzed. Additional analyses related to children's thinking revealed that their explanations can be categorized into looking for likenesses, linking different observations together, or using general ideas; the use of abstractions, however, was not noted. Possible sources of students' ideas about rocks (including their experiences with rocks, particle aggregation, and volcanoes) and implications for classroom practice are also considered. Stressing the importance of students' special language (and confusion surrounding the term "rock"), it is suggested that teachers use the term "rock" to refer to a material rather than an object. (JN)

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LEARNING IN SCIENCE PROJECT (PRIMARY)

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PRIMARY SCHOOL PUPILS' IDEAS ABOUT ROCKS

Science Education Research Unit
University of Waikato
Hamilton, N.Z.

SE 045 309

Working Paper No 107

PRIMARY SCHOOL PUPILS' IDEAS

ABOUT ROCKS

David Symington, Fred Biddulph, John Happs, and Roger Osborne

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A Working Paper of the Learning in Science Project (Primary)

No 107

INTRODUCTION

The topic 'rocks and minerals' has been included at Levels 1, 2 and 3 of the New Zealand Primary Science syllabus [see New Zealand Department of Education, 1980] with resource units being available for teachers at each of these levels.

Research directed at the Forms 1-7 levels by Happs [1982(a)] demonstrated that students at these levels tended to hold a rather restricted view of the term 'rock'. Therefore, it appeared desirable to investigate the ideas that primary children might have in this topic area.

Building upon the ideas of Symington, Osborne, Freyberg and White [1982] it was considered that the investigation could usefully explore:

(i) Children's understanding of the word 'rock'
(ii) Children's ideas about the origin of rock
(iii) Children's ideas about the composition of rock
(iv) The source of children's ideas about rock
(v) The kinds of questions children have, concerning rock
(vi) Children's explanations for their own questions
(vii) The means they use to construct such explanations
(viii) The status they attach to their questions and explanations

This paper reports on exploratory work which addresses some of these issues.

DATA COLLECTION

The data which forms the basis of this paper were collected via 'teaching sessions' and interviews.

The teaching sessions were used to obtain information concerning children's questions and their explanations about rock. This strategy, proposed as part of the Learning in Science Project [LISP (primary)] by Symington, Osborne, Biddulph and Freyberg (1982), requires the teacher to create a situation in which children generate questions about some

natural phenomena. Such questions are recorded and the children then invited to suggest, either individually or in small groups, possible answers to questions selected from the list.

The procedure was used with 10-11 year old pupils in Australia (studied by D.S.) and 8-11 year old children in New Zealand primary schools (studied by F.B.).

Two Australian and four New Zealand classrooms were visited during October/November 1982 for data collection and eighty-six questions were obtained in this way.

The generation of questions was stimulated by allowing pupils a brief "free play" period with a collection of rocks and minerals.

In addition to these 'teaching sessions', two series of interviews were conducted with pupils drawn from two Australian primary schools.

During the first series of interviews, eight pairs of children from each of grades 2, 4 and 6 [48 pupils] were shown a collection of rocks and minerals[1] and asked to:

(i) speculate as to where the sample may have been found,

(ii) indicate whether or not they thought that if they dug down in the school ground and in their garden they would eventually find materials similar to the samples.

In a further group of interviews, five pairs of grade 2-6 pupils were involved. A collection of five rocks and one mineral[2] was placed in front of each pair of pupils who were then asked to explain:

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1. Samples used were : conglomerate, basalt, granite, limestone, quartz and fluorite.

2. Samples used were : conglomerate, basalt, granite, mudrock, limestone, and quartz.

(i) why the samples were so different from each other,

(ii) whether, or not, digging down in the school ground and in their garden would eventually bring them to similar materials.

All interviews were recorded on audio-tape for later transcription and analysis. Information was extracted to obtain some understanding about aspects of primary pupils' ideas concerning rocks and minerals.

ROCK : A PROBLEM OF LANGUAGE

There is a difference between an earth scientist's meaning and the everyday meaning for the term 'a rock'. This has been discussed earlier with reference to older students [Happs, 1982 (b)]. To the scientist, a rock is a fragment of natural material which comprises an assemblage of one or more minerals. In contrast to this view, many older pupils tend to use the term 'a rock' when describing a piece of dense, dark-coloured rock of substantial size [usually fist-sized or larger].

It has also been explained elsewhere [Happs, 1982(b)] how New Zealand students, at the 11-17 year old age levels, tend to use the term 'a rock' in an intuitive way, with criteria such as 'weight', 'colour', 'size' and 'jaggedness' being employed.

Thus a large sample of dull-looking greywacke [a sedimentary rock] was readily described as being a rock by over 80 percent of students interviewed, yet only 26 percent acknowledged that a sample of pumice represented a rock. Students emphasized the 'lightness' of pumice and this aspect, no doubt, led to the conclusion that the pumice fragment should not be regarded as a rock. This was stated explicitly by students. For example:

"Rocks are heavy - pumice isn't heavy."

In interpreting the following data it needs to be borne in mind that these primary children on many occasions may have been using the term rock or rocks in these more restricted ways.

SOME TYPICAL QUESTIONS AND EXPLANATIONS ABOUT 'ROCK' AS PROVIDED BY NEW ZEALAND AND AUSTRALIAN PRIMARY PUPILS

The majority of questions raised by pupils about rocks can be classified into questions about formation, composition, location, colour and durability. We will now consider each of these sets of questions, and explanations relating to the questions, in turn:

(a) QUESTIONS ABOUT THE PROCESS OF FORMATION IN GENERAL

- How did rocks come about? [Aust grade 6]
- How are rocks made? [NZ st 3/4]
- Where did rocks come from in the beginning? [NZ st 2/3]
- Where do they come from? [NZ st 3/4]
- Did all rocks develop from volcanoes? [NZ st 3/4]

and, more specifically:

- How was the first rock formed? [NZ st 3/4]
- This rock has got differenc layers - how did this happen? [Aust grade 6]

Some explanations about the formation of rocks

A number of explanations concerning the formation of rocks were proposed. Many were based on a notion of aggregation:

- In a muddy swamp, all the little stones[3] get stuck in it. The next day it was really dry and it went hard [refers to conglomerate].
- Little pieces crushed together and packed down like all the snow gets packed together [refers to granite].
- Sand gets pushed up by the waves and joins together [refers to limestone].

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3. It has been demonstrated [see Happs, 1982(a)] that Forms 1-7 learners tend to use the word 'stone' when referring to a small rock fragment.

A number of children also associated volcanic activity with rock formation. In the case of the basalt [volcanic rock] a number of suggestions were made regarding its origins.

- From a volcano.
- Some lava got on it and it stayed there.
- It came from an erupting volcano and it was a bit of rock thrown from it and the heat made the outside cool quicker and the inside cools slower and it goes a different colour.
- I think it was caught in some volcanic ash.

It is important to note that although pupils seemed aware of the formation of rocks in association with volcanic activity and through the aggregation of particles, no students mentioned other processes which are frequently referred to by earth scientists, for example, the crystallisation of magma to form plutonic rocks such as granite, or the physical and chemical processes associated with the formation of metamorphic rocks.

Many students expressed uncertainty about the time interval involved in the formation of rocks. However, when such intervals were mentioned, they were usually very short when compared to geological times.

- All the bits of stone move away by the wind and stick in the soft mud [refers to conglomerate]
  [How long would it take to go hard?]
  About a week [one pupil]
  About 50 years [the other pupil]
- I think this one [points to limestone] would come from the beach ... when it rains they [sand particles] all come together and it goes hard from being in the sun.
  [How long would it take?]
  Three years about.

(b) QUESTIONS ABOUT THE COMPOSITION OF ROCKS

The primary pupils raised questions about the composition of rocks,

- What are they made of? [Aust grade 6]
- What are rocks made of? [Aust grade 6]
- What are they made of? [NZ st 2/3]
- What are rocks made of? [NZ st 3/4]

and, more specifically:

- How many different sorts of things does rock take to be formed? [NZ st 3/4]
- Rock sort of changes into other rock. How does it do that? [NZ st 3/4]

Some explanations about the composition of rocks

In describing the composition of rocks, children frequently used such terms as 'sand', 'clay', 'mud', 'stones', 'soil' and 'dirt'.

- [How come rocks are so different?]
  From the soil - there's different kinds of soil so you get different colours.
- That one [points to conglomerate] would be made from sand and stones.
- [How come the rocks are different colours?]
  Because the dirts are different.
- Because the rocks are made out of dirt[4].

In all of the interviews, the word mineral was only used by one pupil although, even in this case, rock formation was still envisaged as a process of aggregation:

- Different minerals of the earth come together.

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4. Many older students see rock as being made from soil. The latter term is often referred to as 'dirt' [Happs, 1982(c)].

Occasionally, pupils' questions revealed some insight into their understanding of specific rock compositions:

- How long does it take for a tree to go into coal?
- How long does it take for a tree to turn into petrified wood?
- How many different types of rock does cooling lava make?

Findings such as these raise questions about the extent to which children's understandings are restricted by their experience or by the fact that they lack any concept of mineral.

(c) QUESTIONS ABOUT THE LOCATION OF ROCKS

Primary pupils generally showed a great deal of interest in finding out where particular pieces of rock had been formed. This is illustrated by questions formally raised in classes:

- Where did the glass kind of rock come from? [NZ st 3/4]
- Where did the black rock come from? [NZ st 3/4]
- Where did you find the rocks? [Aust grade 6]

Some explanations about locations of rocks

In attempting to answer questions about the location of rocks many children suggested, not surprisingly, that rocks had been formed at the point of their location and thus had been 'made' from the materials which exist in the immediate vicinity.

- [Where would you think I found this piece of rock? (points to limestone)]
  At the beach [Why?]
  It's made out of sand. The water mixes the sand and it dries out.
- Near a volcano
- At the beach [Why?]
  The sand sticks together with the water. The waves push it in and it all clumps up.

The responses of the 24 pairs of pupils who were asked to suggest where pieces of rock had been obtained are summarised in Table 1.

These data are interesting for a number of reasons.

(i) They suggest the range of locations which are familiar to children,

(ii) They provide indications about children's thinking about rocks. For example, there were 17 suggestions that the piece of limestone would have come from the beach and this was usually reinforced by comments such as "It looks sandy". Also, the favoured location for fluorite was "In a mine", or "underground" and this idea was reflected in comments such as "You don't see ones like that lying around".

It is obviously important to know if children have an idea that rocks are widespread, even if not visible. Accordingly in the interviews pupils were asked whether, or not, they would find rock by digging under their school or in their yard at home. Responses indicated that a few of the children held a notion of a 'layer of rock round the Earth'. However, the majority of pupils' did not subscribe to this notion and three response categories were identified.

(i) <u>Pupils who believed that digging at any point on the Earth's surface, would eventually yield rock</u>

A number of these children used 'commonsense' arguments:

- There is rock everywhere because if you just had dirt and that and you stepped on it you'd go down if there was no rock there.
- There has to be something hard like rock otherwise all the oil would leak out.
- Rocks hold the Earth together. It's not all loose.

Some of the responses were presented to the interviewer as fact:

- You will hit the Earth if you dig down [what is the Earth made of?] Ice and rock.
- Rock is part of the Earth. There is the core, then ashy stuff, then rock.

SUGGESTED LOCATION	SAMPLE NUMBER					
	1	2	3	4	5	6
At the beach	7	4	11	-	17	-
On the ground	4	6	-	-	2	-
Underground	4	4	3	1	-	9
In creek/river	1	3	-	-	-	-
Under the sea	1	-	-	2	-	4
At a quarry	1	-	-	-	2	-
On a mountain	3	2	4	3	-	3
In a mine	2	1	-	4	1	8
Near a volcano	1	-	-	-	-	-
Desert/outback	1	1	-	-	7	-
In the bush	-	1	5	3	-	1
Pond/swamp	-	-	2	-	-	2
From a cave	-	-	-	1	1	-

TABLE 1: NUMBER OF TIMES A LOCATION WAS SUGGESTED BY PAIRS OF PUPILS AS A POSSIBLE SOURCE FOR A PIECE OF ROCK

KEY:
1 = conglomerate
2 = quartz (white)
3 = basalt (with galeolaria on it)
4 = granite
5 = limestone
6 = fluorite (green)

(ii) Pupils who believed that the distribution of rock under the soil is uneven

Such responses suggested some 'experience' of uneven distribution:-

- On hilly areas but not on flat areas.
- There wouldn't be rock under a swamp.
- You will find rocks where there are mines.
- In the bush - you'd be sure to find rock - but not in inner city areas.

- Under the sea there wouldn't be rock.
- Under some soils - it's really soft - you dig and you don't get rock.
- Only where it's hard ground - not in the desert - the desert's made of sand.
- Depends on whether there's a volcano in the area.
- You would get to rock if you dug where there are rocks.

(iii) Pupils who didn't know about the distribution of rock under the soil:

- You might. I don't know
- You'd get clay but I don't know about rock.
- I'm not sure.

(d) QUESTIONS ABOUT THE COLOUR OF ROCKS

There was little variation with regard to questions about the colour of rock. Such questions included:

- What gives rock its colour? [Aust grade 6]
- Why are rocks different colours? [NZ st 2/3]
- How do rocks get their colour? [NZ st 3/4]

One question referred to the glittering effect of rock material:

- Why do rocks sparkle? [Aust grade 6]

Some explanations about the colour of rocks

In proposing possible answers to the general question "What gives rock its colour?", only seven of the pupils in an Australian class suggested that the colour was due to the material of which the rock was composed:

- It's the colour of the things it's made of.
- Because of the sand it was made out of.

Other responses related to some aspect of the environment:

- Because of the sun.
- Another theory could be that the sun shines on the rock and fades its colour.
- I think the rain gives rock its colour.
- Rocks in the water I would say get their colour from the sea and seaweed.
- The flowers might give rock its colour by rubbing against them.
- Mud gets stuck on them.
- It might roll in dirt and become the colour of dirt.
- Tree leaves might fall down and the greenery might get smudged on the rock.

The interview data also showed the extent to which the environment is seen as determining the colour or colours of a rock or mineral.

> [Where do you think I might have found this? (points to green fluorite)]
> Under the jungle [why?]
> Because of the green colour.
>
> [How come rocks are different colours?]
> Probably from polluted water that runs underground.

(e) QUESTIONS ABOUT THE 'DURABILITY' OF ROCKS

Several questions came to light about the hardness, relative hardness or durability of rocks:

- Are all rocks hard? [Aust grade 6]
- Why are they [rocks] so hard? [NZ st 3/4]
- Why are diamonds harder than any other type of rock? [NZ st 4]
- How long do rocks last? [Aust grade 6]

Some explanations about the durability and hardness of rocks

In one of the classes the question 'How long do rocks last?" was raised. Pupil responses indicated little awareness of the processes of weathering and erosion and the differences between rocks and their individual rates of weathering.

Most pupils simply suggested that rocks would last forever, unless man intervened:

- Rocks last forever.
- I think they last forever unless people break them up.

A few pupils gave some indication that they were aware of weathering:

- I think rocks last as long as their surroundings let them. For instance, the sea and wind pounding on a rock - it would slowly disintegrate and in the bush and in a cool place it would last at least ten times longer.
- Rocks last until they are disintegrated by water or moisture.
- Rock can be dissolved by salt I think. If the sea smoothens the rock it takes some rock off which means it can probably wash away the rock itself.

PUPILS' THINKING

One useful framework for considering the thinking of learners, and their patterns of ideas, has been provided by Bird and Catherall [1976]. They suggested that children's explanations are based on:

(i) looking for likenesses, or
(ii) linking different observations together, or
(iii) using general ideas, or
(iv) using abstractions.

An examination of the data concerning children's thinking about rocks revealed examples from the first three of the above categories, viz.

(i) Looking for likenesses

Human analogies were used by some pupils:

- [Why are these rocks different colours?]
  They grew like that. We're different colours - white people - black people. Different colours and different soils.
- The sun makes the colour of rocks light like our hair gets lighter in colour in the summer.

One pupil 'explained' the layered appearance of one rock by referring to the layering of the Earth:

- It probably has different layers like the Earth has different layers.

Another pupil 'explained' the formation of granite by likening it to the accretion of snowflakes.

- The little pieces get packed down like all the snow gets packed together.

(ii) Linking observations

The most frequent instance of this type of thinking was shown by those pupils who suggested that the sample of limestone must have come from the beach because it looked as if it was made up of sand:

- It looks sandy.
- The sand sticks together with the water.
- It's made out of sand.

(iii) Using general ideas

A number of general ideas were used by pupils as part of their decision making:

- Nice rocks are under the ground and the ordinary ones are on top.
- Bumpy rocks come from under the ground and smooth ones from on top.
- The smooth rocks come from the sea.
- Glittering rocks come from deep down.

(iv) Using abstractions

Pupils involved in this investigation gave no evidence of the use of abstract ideas concerning rocks.

POSSIBLE SOURCES OF PUPIL'S IDEAS ABOUT ROCKS

On the basis of data gathered during the investigations it is possible to speculate about the fomation of pupils' ideas about rocks. The possibilities include:

(i) Pupils' experiences of rock

Apart from a few pupils, such as those whose parents had a particular interest in the earth sciences, the experiences of the pupils with respect to rock appeared to be relatively uniform.

Pupils were generally aware of the use of rocks, both in home gardens and in public gardens. On seeing the piece of quartz, many commented, that they had a neighbour or relative who had similar material in their garden. However, they were often unsure as to whether the substance was there originally or emplaced at a later date.

Many pupils had seen rock in various locations but the most common location was at the beach. Data from Table 1 suggests that the beach is a principal source of experience about rocks.

Comments about rocks at the beach did not reflect [as is to be expected] any information concerning the type of rocks present; rather they alluded to the smoothness of rock exposed to the water, the algae and encrustations on the rock and changes in the appearance of rock as it dried out.

(ii) Pupils' experiences of particle aggregation

Most pupils appeared to have had first-hand acquaintance with the way in which moist soils and clay can be moulded and dried by the sun to form small aggregates of material. Pupils tended to draw on such experience in describing how they believed both the conglomerate and the limestone samples had been formed.

(iii) Pupils' experience/knowledge of volcanoes

Many pupils indicated that they were aware of the existence of volcanoes and that lava can flow from them. Volcanic activity is frequently used as a 'backdrop' to fiction, films and television dramas, yet few of the pupils interviewed had any notion as to what rocks formed from lava would be like. Australian children, as might be expected, generally perceived volcanic activity, and associated landforms, to be overseas phenomena.

THE INVESTIGATIONS AND CLASSROOM PRACTICE

Up to the present, the teaching about rocks and minerals in primary and secondary schools has been influenced largely by what it is believed pupils are expected to know [as defined by science prescriptions] and what it is believed they are capable of understanding.

The aim of this paper has been to provide data which will allow us, as teachers, to be more sensitive to the ideas pupils have, and their thinking about rocks. Furthermore, information has been sought concerning what pupils say they would like to know about rocks which, in turn, appears to be influenced by their present level of knowledge and understanding.

At present, our awareness of pupils' thinking, and which teaching strategies might best be employed to capitalise on this information is limited. However, it does seem desirable to draw attention to the direction in which we believe this data is taking us.

(a) Interest

There is little doubt about the ability of pupils to ask questions about rocks, given an appropriate context and opportunity. It would seem appropriate therefore to recommend that teachers create situations which are favourable to the asking of questions and that the questions pupils raise be documented and used, in part, as the basis of future classroom activity.

Table 2 shows that there are aspects about rocks which are likely to be of interest to many primary school pupils:

TABLE 2: TOPICS IN WHICH THERE MAY BE WIDESPREAD INTEREST AS GAUGED BY QUESTIONS RAISED BY PUPILS IN TWO AUSTRALIAN AND TWO NEW ZEALAND CLASSES

	Aust Classes		NZ Classes	
How rocks get their colours	✓	✓	-	✓
What rocks are made of	✓	✓	✓	-
Processes of rock formation	✓	✓	✓	✓
The shape of rock pieces	✓	✓	✓	✓
The hardness of rocks	✓	✓	-	✓
Valuable materials, eg diamonds/gold	✓	✓	✓	-

The fact that certain issues are frequently raised by pupils must encourage us to look at whether, or not, they can be adequately dealt with in the primary classroom.

(b) Pupils' answers to some questions about rocks

This paper documents some of the answers that pupils have proposed, in response to questions about rock. It seems worthwhile to consider the range of possible answers offered and to draw attention to the collection of typical 'answers' as one procedure which might provide further insight into the learner's understanding about rocks. In addition to such useful information, a number of proposed 'answers' may prove capable of being assessed by the pupils, either by seeking authoritative information or by the setting up of simple experiments to probe possible solutions.

(c) The importance of the pupils' special language

It has already been stressed that learners, at all levels, tend to use the word 'rock' as implying a rock fragment of fist-size, or larger, with terms such as 'stone'[5] and 'boulder'[6] being employed to describe rock material, either smaller or larger than 'rock-size'.

The confusion surrounding the scientific meaning of terms such as 'rock' is often compounded when textbooks on rocks and minerals assume that the reader understands the term 'rock' as referring to rock fragments of any size.

One important contribution which the teacher can make to the learner's understanding in this area is to actively encourage the use of the term 'rock' to refer to a material rather than an object. Various sized fragments of rock have specific names to an earth scientist eg. clay, sand, pebble, boulder (see Table 3). An appreciation of this distinction is something understandable by 8-11 year olds and could usefully precede any information given to pupils about the names, composition and modes of origin of different rock.

Work in progress [Happs, 1983] is directed at developing teaching sequences for secondary school pupils which better takes into account students' ideas on this topic. Undoubtedly some of this work will have relevance for younger children. However, this has yet to be explored.

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5. The term 'stone' is commonly used in an everyday sense, eg. the girl picked up the stone and threw it into the sea. This implies a rock fragment of small size, yet the earth scientist does not place any size connotation on the word 'stone' and generally does not use the term at all.

6. The word 'boulder' usually refers to a rock fragment more than 200 mm in diameter.

TABLE 3 : SIZES OF ROCK FRAGMENTS

Name	Diameter
Boulder	More than 200 mm
Cobble	200 - 50 mm
Pebble	50 - 4 mm
Granule	4 - 2 mm
Sand	2 - .02 mm
Silt	.02 - .002 mm
Clay	less than 0.002 mm

NOTE: Gravel usually means pebbles, granules and cobbles.
Mud is a collective name for clay and silt sized particles.

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